Massachusetts Aquaculture Grant
Submerged Coastal Offshore Mussel Aquaculture System (SCOMAS)
Biological Aspects of Suspended Near Bottom Growth
Near the Benthic Turbidity Zone (BTZ)

Final Report

Period: January through June 30, 1999

Prepared by George Hampson, Biology Department, with support from Porter Hoagland and Hauke Kite-Powell, Marine Policy Center, and Walter Paul, Department of Applied Ocean Physics and Engineering[1]

1.0 INTRODUCTION

This is the Final Report of the biological portion of the SCOMAS project funded by Massachusetts Aquaculture Grant RFR Number AGR-AQUA-298. It is covering the work done in the first six months of 1999. Last year's work from February through December 1998 was summarized in a Progress Report submitted to the Massachusetts Department of Food and Agriculture at the end of 1998. The Progress Report covered the start of the project including the deployment of the long-line in October. The 1998 report can be resubmitted upon request.

2.0 WORK PERFORMED IN 1999:

2.1 Reconnaissance SCUBA Dive

Dive to large submerged rock off Plymouth MA on May 6 to establish presence and size of mussel spat at that location. Dive team: G. Hampson and E Horgan (WHOI divers).

2.2 Collection of Seed Mussels

A five member diving team, four from Aubrey Consulting Inc., was organized. The team removed 375 lbs of mussel spat from the submerged rock off Plymouth MA on May 25. Size and distribution of the seed stock is listed in Appendix A. Aubrey Consulting donated the services of four divers as cost sharing to the mussel project to assist in the tedious collecting work. This effort by Aubrey Consulting was considerable in terms of effort and energizing our offshore deployment program.

2.3 Mussel Socking

The 375 lbs. of seed stock were filled into socking by Blue Gold Inc. of New Bedford on May 26. Blue Gold developed the method, executed the critical filling of the socks with seed mussel, and delivered them in a large suitable container to the WHOI dock in Woods Hole.

[1] This project is part of a three contract effort funded in 1998 at WHOI. The two additional grants are: *Understanding the Potential of Offshore Marine Aquaculture: A Bioeconomic Approach* by Porter Hoagland, Di Jin, and Hauke Kite-Powell from the WHOI Marine Policy Center, funded through the WHOI Sea Grant Office; and *Submerged Coastal Offshore Mussel Aquaculture System (SCOMAS)* by Walter Paul and Mark Grosenbaugh from the WHOI Applied Ocean Physic and Engineering Dept., funded as Regional Program by the MIT Sea Grant Office.

2.4 Partial Deployment of Mussel Socks at Sea

Inspection of the long-line and partial deployment of the mussel socks at sea took place at the WHOI Buoy Farm site on May 28,1999. In order to gain access to the long-line it is partially raised above the sea surface by the service vessel. A small number loops made of socking material, furnished with a center rope to provide sufficient strength, was attached to the long-line and deployed. The mussel team could participate in a voyage of the R.V. *Connecticut*, funded under a grant to WHOI by the Office of Naval Research, for a small fraction of the charter cost of a suitable vessel by the mussel project. WHOI's Dr. Grosenbaugh had organized the cruise to recover buoy systems engaged in a hydrodynamic monitoring and verification test.

2.5 Final Deployment of Socked Seed Mussels at Sea

The WHOI Buoy Farm site was revisited on a designated cruise of the R.V. *Asterias* on June 2. Funding for salaries and ship time for this trip was covered by a grant from the Marine Policy Center of the Woods Hole Oceanographic Institution. Twelve seeded sock loops were attached to and suspended from the long-line. Also suspended were a small number of mussel socks without seed to investigate if natural set would develop with time, see Figure 1. The overall length of the loops varied between 46 and 150 ft. All loops were suspended from the longline that was raised by the R.V. *Asterias* for this purpose. At the bottom of each loop a weak link was installed as required by the Army Corps of Engineers' permit for the offshore mussel project. The purpose of the weak link is to allow a large marine mammal to free itself from a possible entanglement in a suspended mussel socking loop.

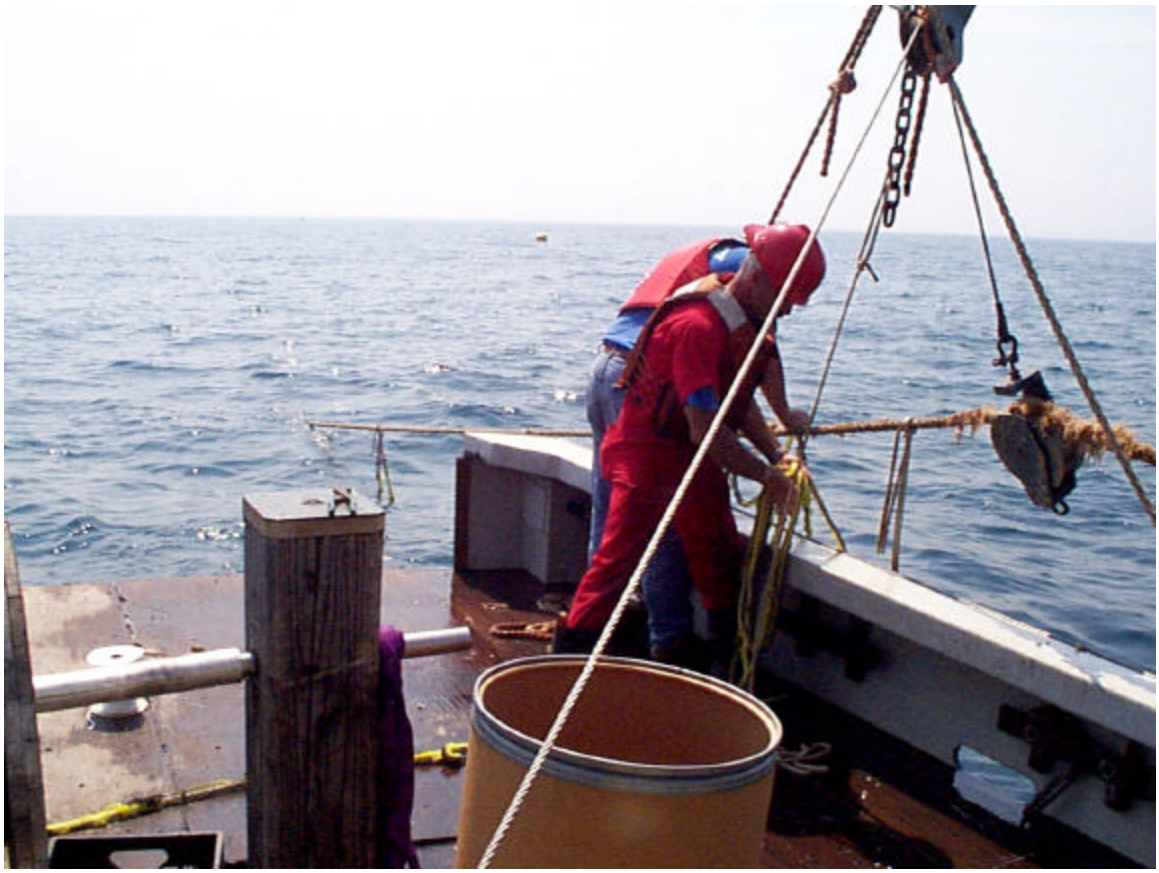

Figure 1: Attaching Mussel Socks to the Longline

2.6 Observations at Sea

Upon raising of the submerged long-line to a position above sea level alongside of the R.V. Connecticut and the R.V. Asterias in May and June an amazingly large growth of self seeded hydroids (Tubularia spp.) and mussels was discovered, see Figures 2 and 3. The 1.25 inches diameter longline had grown to up to five inches in diameter with marine growth during its 8½ month submerged exposure to the waters at the Buoy Farm. Growth pattern along the line varied in mussel density, but the frequently large accumulations of mussels were always associated with abundant colonies of hydroids.

Figure 2: A First Look at the Long-Line after 8 Months at Sea

Four single-110ft spat collectors ropes, which were suspended from the long-line on December 5, 1998, were partially lifted by hand on the Asterias voyage on June 2, but not retrieved due to excessive weight of accumulated growth. Assessment of the growth and growth distribution will be performed at a future visit to the site, with more suitable lifting and weighing equipment on hand to raise the suspended ropes and determine the needed additional floatation to support the mussel weight.

2.7 Summary of Biological Assessment

- Wild mussel spat was found to settle abundantly and successfully within the dense colonies of hydroids and appeared to compete successfully for space and food with this known aggressive planktonic/larval consumer.

- Deployment of spat collectors in early December does not preclude the growth of Tubularia spp. as a major biofouling factor.

- Horizontal growth patterns of mussel spat concentrations along the harness were not uniform. Also, mussels appeared to be settling and growing clear to the bottom. This observation was

made from several small deeply submerged mooring floats that were collected from oceanographic moorings deployed at a similar period.

Figure 3: Another Look of the Mussel and Hydroid Covered Long-Line

- Several other species of invertebrates (polychaetes, tunicates, nudibranches) were found living along the longline surface, but not a single specimen of Asterias (starfish), a major predator, was detected in the field.

- Mussels taken from the long-line did not show any traces of current pea crab infestation, they showed no gill or mantle damage which would indicate past infestation either. No other macroparasites like copepods or worms were found on the mussels, the mussels stand out for their cleanliness.

- Size distribution of mussel collected from the mussel harness on the May 28,1999 voyage is found in Appendix A.

3.0 Problems Encountered and their Effects on Reaching the Project Goals

Encountered problems were either of delaying or biological nature.

- A late start of he project was forced by the delay in obtaining the permit to install a submerged long-line mooring system at the WHOI Buoy Farm site. The U.S. Army Corps of Engineers issued the permit (No. 199800289) in August 1998, six month after filing for the permission. The spring spawning season of the blue mussel in 1998 was therefore missed, delaying the start of the mussel growout by one year.

- The planned collection of suitable seed mussels from a large submerged rock off Plymouth, Massachusetts, in the late fall of 1998 had to be postponed. A week prior to the planned collection divers found that the abundant mussel growth on the rock was suddenly completely killed off, probably by offshore pollution. We had to wait till June 1999 before a new seed mussel set had developed in sufficient quantity to allow harvesting, subsequent socketing, and deployment at the WHOI Buoy Farm site. Again the important spring season for rapid mussel growth had been missed.

- The budgets for this project are marginal and require continued solicitation to secure more funding to cover the cost of the project, which takes time away for the execution of the job.

The encountered problems are delaying the end of the project. The scheduled fall 2000 completion date may have to be postponed in order to allow assessment of the success of the project. So far no further problems were encountered.

4.0 Effects of Project Results on the Massachusetts Aquaculture Industry

The observed abundant wild set of mussels on ropes in the waters of the WHOI Buoy Farm site is considered of significant value. It may eliminate or reduce the need to secure seed mussel and insert them into socking material in order to start a mussel offshore aquaculture project. It may be sufficient to suspend a growout harness from submerged long-lines, and use the natural spat set seed material for the growout process. This would result in noticeable (10 to 20 percent estimated) cost savings for mussel aquaculture operators.

The final assessment of the success or failure of this project can only be made at the time of the harvest of the mussels at the end of next year or may be in 2001. If successful, the introduction of commercial offshore aquaculture of blue mussels will depend on the availability of designated offshore sites off the Massachusetts coast. If sites will be made available, the economic impact would be significant. Offshore mussel farming cooperatives or other enterprises can be established with the business goal to engage in offshore mussel aquaculture. If the Canadian and Australian enterprises can be a guide, a small but significant new industry could flourish.

The environmental consequences of offshore mussel aquaculture would be minimal if at all noticeable. The mussels are suspended in an open ocean environment with sufficient current flow (typical 0.4 meter/second at the site) to constantly supply fresh water and flush mussel feces away. The wide spacing of the mussel socks is avoiding problems encountered with high density aquaculture of finfish in fish cages.

The potential risks that can affect this project are significant. On the biological end, disease or predators could destroy the mussel stock. The structure may collapse due to local abrasion, fatigue failure, or cutting by fishing gear, which could be catastrophic.

So far our outreach has been limited. A large poster was created, which was first shown at the annual open house of the Rhinehart Coastal Research Center at WHOI on June 11 1999, a copy of the poster has been sent to the Massachusetts Dept. of Agriculture. Talks about the project were given at the Center for Marine Science and Technology (CMAST) of the University of Massachusetts in New Bedford, at a Mussel Forum with Aquaculturists in New Hampshire, and an Aquaculture Meeting in Maine. The true outreach through talks and presentations will

have to wait till the end of the growout test. We would be glad to report about this work at appropriate meetings and conferences.

Despite the limited progress so far this is a very exciting project, both simple and very complex, and despite all preparations full of surprises. A great deal has been learned and the natural mussel set experienced has made it all worthwhile.

Fig. 4: A small Sample of Seed Mussels Grown on the Long-Line

5.0 Conclusion and Future Plans

The natural set and growth of blue mussel on the submerged long-line is overwhelming and encouraging. During the continuation of the mussel project through the summer of the year 2000 a number of questions will hopefully be answered. Suspended mussel sock without any seed mussel may be sufficient to attract economical quantities of seed mussel, the comparison with the development of the suspended socks with seed mussels will bring clarification. Quantitative assessment of the mussel growth will be input for the economic forecasting of offshore mussel profitability. Important questions on predation and survivability of the mussels through sufficient growout will be answered.

On the engineering side the field experience with the deployment and servicing has been invaluable. Engineering is developing an improved grapnel/roller sheave device for easier and safer pickup and servicing of the long-line. Improved hydrodynamic modeling of the longline with its suspended mussel harness is progressing. The *WHOI Cable* software package allows the determination of mooring forces, the displacements and geometry changes due to sea state and current forcing, acceleration of any portion of the harness and mooring system as function of the selected sea state. Modeling results with different dimensions and weights of the mussel growth allow the determination of additional flotation requirements as the growout progresses. The

behavior of each temporary configuration is predicted under hurricane wave conditions, and its chance of surviving is estimated. In addition details of the longline deployed geometry and its displacements under servicing conditions by a visiting vessel have been analyzed and the limits of the geometric setup determined. The resulting knowledge of the engineering understanding is considered vital for a potential commercial development of mussel offshore aquaculture.

6.0 Acknowledgements

The assistance of the following individuals and organizations has helped to move this project forward:

- Mr. Steve Aubrey from the Woods Hole Group for diving support to secure seed mussels from an offshore location.
- Dr. John Bonardelli from GRT Aquatech-Technologies, Quebec, Canada, for thorough advice on details of the mussel long-line technology and mussel biology issues.
- Mr. Don Bishop from Fukui North America for the donation of 1000 meter socking material for the project.
- The late Dan Clark of Woods Hole, who had the wisdom, sprit, and generosity to sponsor the prototype of this project over 10 years ago.
- Blue Gold, New Bedford, through its President Mr. Link Murray and its manager Mr. Dave Kolator. Significant in-kind support was received with ship support, socking and transportation of mussels.
- Dr. Mark Grosenbaugh from the Woods Hole Oceanographic Institution for allowing our participation on a ship visit to the Buoy Farm site on May 28.
- The Marine Policy Center of the Woods Hole Oceanographic Institution for the funding of the mussel sock deployment trip of R.V. *Asterias* on June 2.
- Dr. John Pearce provided in-kind help with the analysis of the mussel stock from the Buoy Farm site, checking for predators and infestation by disease.
- Dr. Donald C. Rhoads in assessing the presence of resuspended food particulates at the deployment site and their impact on mussel growth, and helping with mussel tissue analysis and determination of infestation by pea crabs and others.
- Mr. Rod Dorr for loaning our project two, 4000 lb DorMor anchors.

Last not least we greatly appreciate the support of the Massachusetts Aquaculture Program, which made the biological component of the offshore mussel project possible.

APPENDIX A

POPULATION OF SEED MUSSELS

COLLECTED FROM

WATERS OFF PLYMOUTH, MASSACHUSETTS

May 25, 1999

APPENDIX B

MUSSELFARM PROJECT POSTER

Original Displayed at the

ANNUAL OPEN HOUSE

of the

RHINEHART COASTAL RESEARCH CENTER

at the

Woods Hole Oceanographic Institution

June 11, 1999

APPENDIX C

FINAL BUDGET OF ANNUAL EXPENSES